www.ijsrnsc.org

Available online at www.ijsrnsc.org

IJSRNSC

Volume-5, Issue-2, May 2017
Research Paper

Int. J. Sc. Res. in Network Security and Communication

ISSN: 2321-3256

A Novel Design of Compact Planner UWB Antenna with Multiple Band Rejection Function

RC. Jain[1*], MM. Kadam[*2]

[1]Department of Electronics & Telecommunication Engineering, ARMIET, Mumbai, India
2 Dept .of ETE, TERNA Engineering College, Navi Mumbai, India
Corresponding Author: mahesh_kadam72@rediffmail.com

Received 22th Feb 2017, Revised 30th Feb 2017, Accepted 16th Mar 2017, Online 30th May 2017

Abstract— A compact printed Y-shape ultra-wideband(UWB) antenna with multiple band-notched characteristics is presented. The proposed antenna, with compact size of 30×32.5×1.6 mm^3, yields an impedance bandwidth of 2.5-11 GHz for VSWR < 2, except the notched bands. By removing two C-shaped slots in the radiating patch, and one U-shaped slot in the microstrip line, triple band-notched properties in the WiMAX/WLAN/X-band satellite bands are achieved. A prototype of the UWB antenna with multiple notched bands is fabricated and the measured results of the antenna are compared with the simulated results. The proposed antenna exhibits nearly omni-directional radiation pattern and a stable gain over the entire impedance bandwidth except for the three notched bands.

Keywords— *UWB, Triple Band Notch ,C-shaped slot, U- shaped slot, WiMAX, WLAN, X-band satellite*

I. INTRODUCTION

In last decades, the ultrawideband (UWB) technology is developed widely and rapidly. it become very popular in high speed short range communication systems., for broadband and ultrawideband (UWB) applications, patch antennas are an attractive candidate due to their light weight, low cost, wide bandwidth, compact size, and ease of fabrication..... However, with such a wide bandwidth, UWB antenna would have interference with some of the existing communication system for instance, WiMax (wireless interoperatibility for microwave access) for at 3.3 - 3.7 GHz, WLAN (wireless local area network) IEEE 802.11a operating at 5.15 - 5.85 GHz and X band satellite communication operating at 7.25 GHz - 8.395 GHz. It is essential to design an antenna which is not only compact and planar but also has Multiple Band Rejection Function to protect the UWB based applications from possible interference from existing narrow band services
To overcome problems caused by this interference, several designs of UWB antennas with single or multiple notch functions have been proposed in recent literature
Reviewing the literature shows that there are few ways for to achieve band-notched characteristics. The most popular approach is cutting different shaped slots from the radiating patch, from the ground plane, or from the feed line, that is, U-shaped slot , a Hilbert-curve shaped slot , cutting a wide line , T-shaped slot, defected ground structure (DGS) , semicircular slot , a bent slot or C-shaped slot , split ring in the ground plane , and slot line in the feed line Another way consists of loading diverse parasitic elements on the antenna, such as parasitic elements rear or near the radiating element , and near the feed line [2-26]

above techniques can achieve band notch characteristics, but some of the notched band structures are complex and difficult to design. In the designing of multiple band notch antenna, it is difficult to adjust and to control the frequency centre of the notch bands in a limited space. Moreover, strong couplings between the band-notched characteristics designs for adjacent frequencies are the complication in achieving efficient band rejection of UWB antenna.

In this paper, we propose a simple and compact microstrip line fed planar UWB antenna with triple band-notched characteristics in 3.5 GHz(3-4 GHz) ,5.5 GHz(5-6 GHz) and 7.5 GHz (7–8 GHz),The triple band-notched characteristic in the proposed antenna can be achieved by removing two C-shaped slots from radiator and U-shaped slot from microstrip line. The radiating patch is having a Y-shape structure.

It has been observed that by adjusting the total length of the C- shaped and U-shaped slot to be approximately half wavelength (λ)of the required notch frequency, a destructive interference takes place making the antenna non-radiating at that notch frequency.

The tuning of the central notch frequency can be done by adjusting .The total length of each slot can be calculated by (1), at which the slots resonate at the corresponding band notching frequency, and its total length is equal to a half wavelength as follows.

$$\mathbf{L_{total}} = \frac{\mathbf{c}}{\mathbf{2f_{notch}}\sqrt{\boldsymbol{\varepsilon}_{\mathbf{eff}}}} \qquad (1)$$

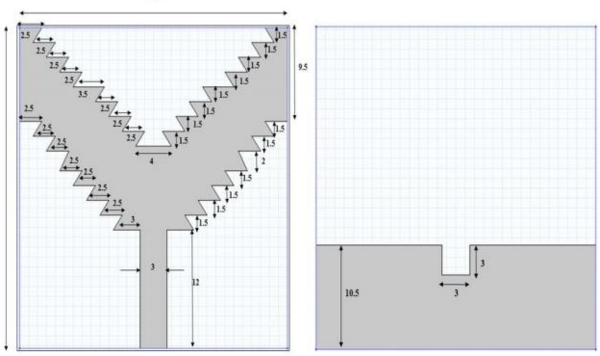
$$\text{Where} \quad \boldsymbol{\varepsilon}_{\mathbf{eff}} = \frac{\boldsymbol{\varepsilon}_{\mathbf{r}}+\mathbf{1}}{\mathbf{2}} \qquad (2)$$

$\mathbf{L_{total}}$ denotes the total length of the corresponding slot; $\boldsymbol{\varepsilon}_{\mathbf{eff}}$ is the effective dielectric constant of the

substrate; and **C** is the speed of light in free space.
The optimization of the design and the subsequent simulation is done by COMSOL Multiphysics software. The proposed antenna provides bandwidth of 3.1-10.6 GHz with $VSWR \le 2$, except the bandwidths of 3-4 GHz for WiMAX system, 5-6 GHz for WLAN system and 7-8GHz for X-band satellite communication band.The designed antenna with optimal dimensions was fabricated and tested **.**

II. ANTENNA GEOMETRY

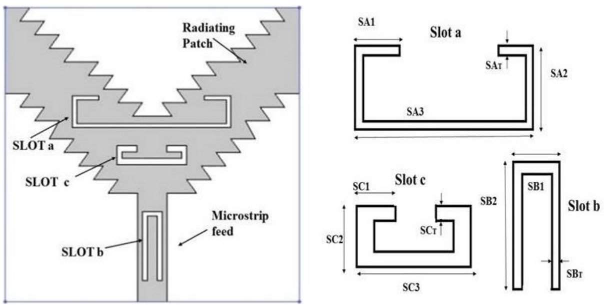
The geometry of the proposed antenna is shown in Fig. 1, The antenna has a compact geometry of 30 x 32.5 mm^2 With FR4 substrate of thickness 1.6 mm and dielectric constant $\boldsymbol{\varepsilon_r}$ =4.4, The antenna is fed through a 50Ω microstrip line. The partial rectangular ground plane having a rectangular cut just beneath the microstrip feed line on the other side of the FR4 substrate ground plane to achieve wide impedance bandwidth.



(a) (b)

Figure 1.The design geometry of proposed initial monopole UWB antenna. (a) front view. (b)back view

Fig .2 shows layouts of proposed UWB antenna with three band-notched slots. The triple band-notched properties are observed with three band-notched elements such as slot a, slot b, slot c, at 3.5,5.5, and 7.5, GHz, respectively. To ensure least mutual coupling, the dimension and position of triple band notched elements have been optimized in our proposed design. However, each band-notched element has been tuned independently.



(a) (b)

Figure 2 (a) Layout of proposed UWB antenna with three band-notched (b) Layout of the slots with its parameters
Dimensions of the proposed UWB antenna with optimized parameters of antenna geometry in Fig.1 and slots shown in Fig.2. (b). are as follows SA1=2.7 mm, SA2=3.5mm, SA3=16.15mm, SA_T=0.4mm, SB1=2mm, SB2=7.6mm, SB_T=0.5mm, SC1=2mm, SC2=2.1mm, SC3=7.1mm, SC_T=0.7mm

III.SIMULATION RESULTS AND DISCUSSION

1.VSWR

Fig. 3 shows the simulated VSWR of reference antenna without any slot. The simulated response indicates a wide impedance bandwidth from 3 GHz to 11 GHz for VSWR<2.The wide impedance bandwidth can be attributed to optimized value of gap between the radiator and the ground plane.

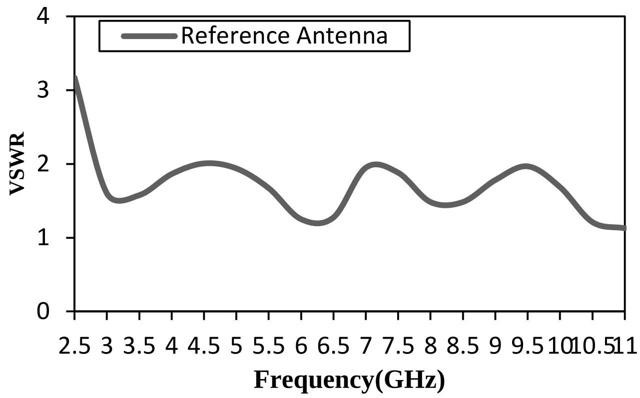


Figure 3 Simulated VSWR of antenna without slots

Fig. 4 shows the evolution of design of proposed UWB antenna from initial antenna. The slots for band notched characteristics are introduced individually and analyzed in terms of VSWR for each slot. The antennas labeled as a, b and c have been designed to notch frequency bands centered at 3.5, 5.5 and 7.5 GHz.

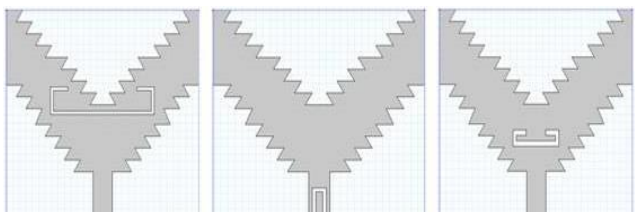


Figure 4 Geometry of UWB antenna having individual slots on radiating patch and microstrip line

The simulated VSWR of antenna having individual slots is shown in Fig. 5. It is noted that antennas a, b and c are able to notch frequency bands individually centered at 3.5 GHz, 5.5 GHz and 7.5 GHz, respectively. The location of each slot is different on the radiator patch so they do not interfere with notched bands created by other slots.

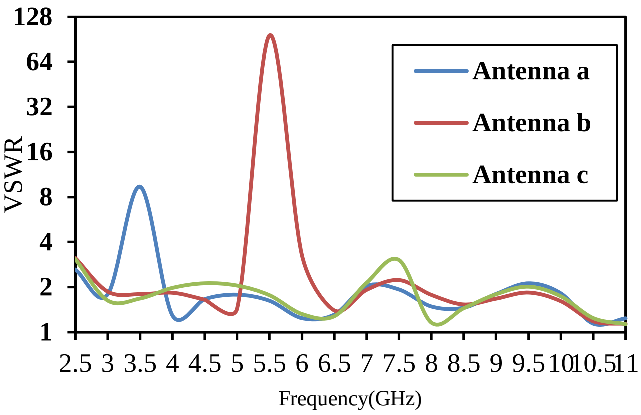


Figure 5 Simulated VSWR of UWB antennas a, b, and c.

After simulating the individual band notched function, the three slots are then incorporated in a single antenna.
The three stop bands have been generated by using two C-shaped slot in the radiator patch a U-shaped slot in the microstrip feed line. Each slot is able to notch the frequency band depends upon the length, width and gap of the slot.

Simulated VSWR of designed antenna is shown in Fig. 6. The acceptable VSWR should be <2 except three notch band. First notch band was created between frequencies of 3GHz to4 GHz by slot a with center frequency of 3.5GHz. Second notch band was created between frequencies of 5 GHz to 6 GHz by slot b with center frequency of 5.5 GHz. And third notch band is obtained between frequencies of 7 GHz to 8GHz by slot c with center frequency of 7.5 GHz, which can eliminate the interference with WiMAX, WLAN and X-band system.

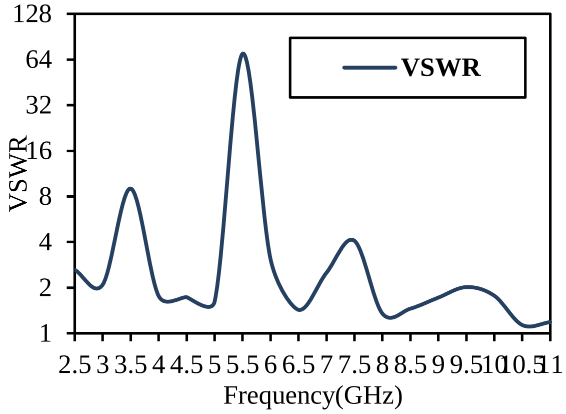
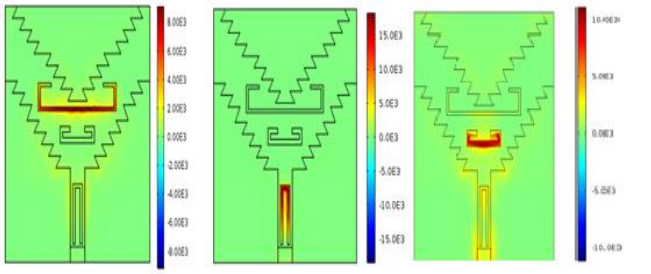


Figure 6 Simulated VSWR of proposed UWB antenna

2 .CURRENT DISTRIBUTION

Fig.7. shows analysis of the band notched characteristics with surface current distribution at notched frequency of 3.5, 5.5 and 7.5 GHz, the three slots have considerable current concentration around the slots which acts as resonators. The current in radiator patch is quite small and hence, it does not radiate. At the same time, the ground plane has large surface current flowing through it which makes the antenna to be non-responsive at that frequency.

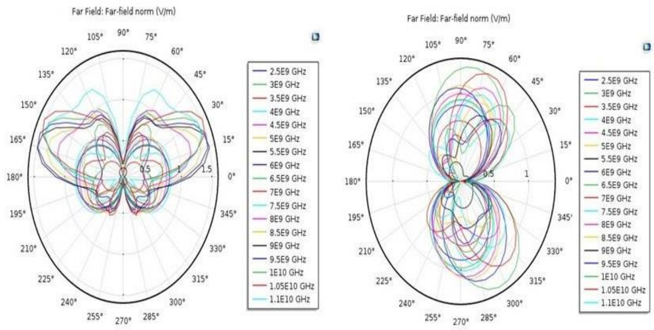


(a) (b) (c)

Figure 7 Simulated surface current distribution of proposed antenna at three notch frequencies (a) 3.5 (b) 5.5 and (c) 7.5GHz

3.RADIATION PATTERN

The simulated normalized far-field radiation patterns of antenna are shown in Fig 8. It is seen that the antenna shows a nearly omnidirectional radiation pattern in the H-plane shows that the antenna is able to retain its omni-directional behavior at lower frequencies while there is little variation at higher frequencies to simulated response. The E-plane radiation pattern is bi-directional in nature at lower frequencies, the radiation pattern at higher frequencies deteriorates because the equivalent radiating area changes with frequency over UWB



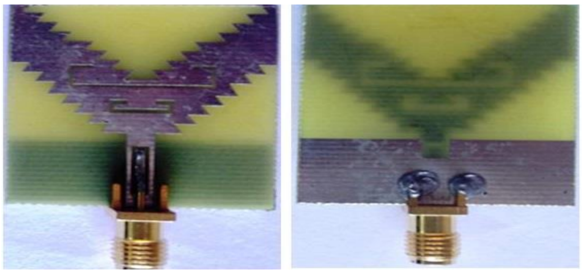
(a) (b)

Figure 8 simulated radiation pattern in(a) E-plane
(b) H- plane

VI. HARDWARE IMPLEMENTATION AND EXPERIMENTAL RESULTS

A compact planner UWB antenna with multiple band rejection function is fabricated and tested using Agilent Technologies FieldFox Microwave Analyzer (N991GA-14GHz). The top view and bottom view of fabricated antenna is shown in Figure. 9. The return loss S_{11} characteristics of the fabricated antenna is shown in the Figure. 10.

The Figure 11 shows measured VSWR of proposed Antenna.
The measured impedance of an antenna is close to a 50Ω as shown in Figure 12.



(a) (b)

Figure 9.(A)Front view(b)Back view of proposed fabricated antenna

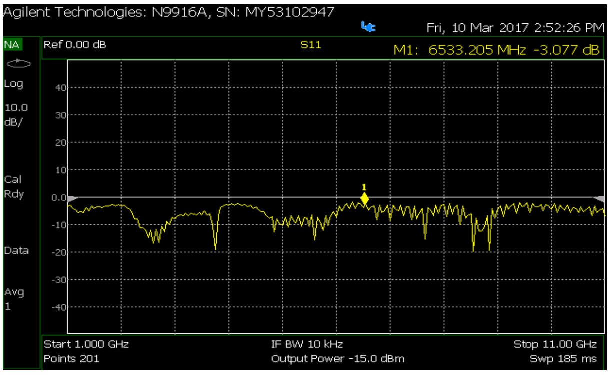


Figure 10 Measured S_{11} of proposed antenna

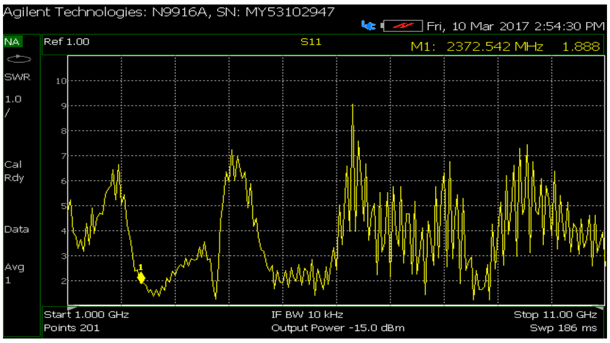


Figure 11 Measured VSWR proposed of antenna

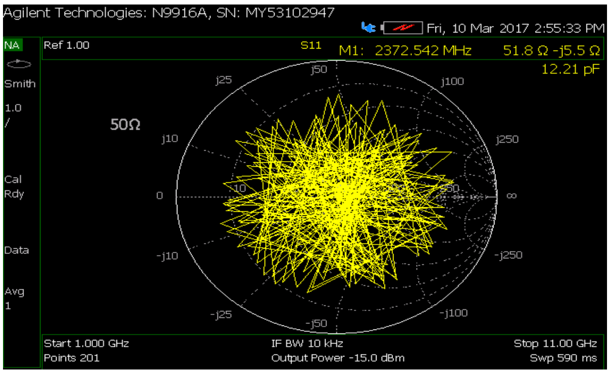


Figure. 12. Measured impedance of proposed antenna

The measured results appear to be slightly differ from the simulated results. This may be attributed to fabrication issues such as bumps caused by the solder, slight curvature of substrate due to its flexible nature, influence of feeding cable and the minor changes in the air gap height. It can be seen that reasonable agreement has been achieved between the simulated and measured results.

V. CONCLUSION

In this work, a UWB antenna, with multiple band rejection, has been successfully implemented and investigated. The notched-bands can be easily tuned to the desirable frequency location by controlling the parameters of the notch. The proposed antenna covers the frequency range for the UWB systems, between 3 GHz and 11.0GHz, with a rejection band around WiMAX, WLAN, and X-Band services. The introduced notches are blocking undesired narrow band radio signals appeared in UWB band. The proposed planar monopole antenna is very useful for modern UWB wireless communication systems.

ACKNOWLEDGMENT

I would like to thank my guide Prof.Mahesh.M.Kadam for the help, guidance and encouragement during various phases of this project work ,my college ARMIET for their support and guidance. Terna College of Engineering for providing necessary facilities for antenna testing.

REFERENCES

[1] GR Aiello, GD. Rogerson, "Ultra-wideband wireless systems", IEEE microwave magazine, Vol.4, Issue.2, pp.36-47, 2003.

[2] R. Azim, MT. Islam, N. Misran, "Microstrip line-fed printed planar monopole antenna for UWB applications", The Arabian Journal of Sciences and Engineering, vol. 38, Issue.9, pp.2415-2422, 2013.

[3] AA. Adam, SKA. Rahim, KG. Tan, AW. Reza, "Design of 3.1-12GHz printed elliptical disc monopole antenna with half circular modified ground plane for UWB application", Wireless Personal Communications, Vol. 69, Issue.2, pp. 535-549, 2013.

[4] R. Gonc¸alves, P. Pinho, NB. Carvalho, "Compact frequency reconfigurable printed monopole antenna", International Journal of Antennas and Propagation, Vol.2012, Issue.1, pp.1-7, 2012.

[5] X. Kang, H. Zhang, Z. Li, "A band-notched UWB printed half elliptical ring monopole antenna", Progress in Electromagnetics Research C, Vol.35, Issue.2, pp. 23-33, 2013.

[6] A. Karmakar, R. Ghatak, U. Banerjee, DR. Poddar, "AnUWB antenna using modified Hilbert curve slot for dual band notch characteristics", Journal of Electromagnetic Waves and Applications, Vol.27, Issue.13, pp.1620-1631, 2013.

[7] L. Bing, JS. Hong, "Design of two novel dual band notched UWB antennas", International Journal of Antennas and Propagation, Vol. 2012, Issue.4, pp.1-7, 2012.

[8] N. Ojaroudi and M. Ojaroudi, "Novel design of dual band notched monopole antenna with bandwidth enhancement forUWB applications", IEEE Antennas and Wireless Propagation Letters, vol. 12, Issue.1, pp. 698-701, 2013.

[9] S. Soltani, M. Azarmanesh, P. Lotfi, and G. Dadashzadeh, "Two novel very small monopole antennas having frequency band notch function using DGS for UWB application", International Journal of Electronics and Communications, vol. 65, Issue.1, pp.87-94, 2011.

[10] T. Li, H.Q. Zhai, C. Zhu, L. Li, C.H. Liang, Y.F. Han, "Design and analysis of compact printed dual band-notched ultrawideband (UWB) antenna", Journal of Electromagnetic Waves and Applications, vol. 27, Issue. 5, pp. 560-571, 2013.

[11] S.M. Zhang, F. S. Zhang, W.Z. Li, T. Quan, HY. Wu, "A compact UWB monopole antenna with WiMAX and WLANband rejections", Progress in Electromagnetics Research Letters, vol. 31, pp. 159-168, 2012.

[12] P. Gao, L. Xiong, J. Dai, S. He, Y. Zheng, "Compact printed wide-slot UWB antenna with 3.5/5.5-GHz dual band-notched

characteristics", IEEE Antennas and Wireless Propagation Letters, vol. 12, pp. 983-986, 2013.
[13] SK. Mishra, RK. Gupta, A. Vaidya, J. Mukherjee, "Low-cost compact printed circular monopole UWB antenna with3.5/5.5-GHz dual band-notched characteristics", Microwave andOptical Technology Letters, vol. 54, Issue. 1, pp. 242-246, 2012

[14] J. Kim, N. Kim, S. Lee, "A broadband antenna usingthe modified ground plane with a complementary split ringresonator for 5-GHz WLAN band-notched performance, "Microwave and Optical Technology Letters, vol. 54, Issue. 1, pp. 1-3,2012.

[15] MA. Amin, "Design of a CPW-fed band-notched UWB antenna using a feeder-embedded slot line resonator", International Journal of Antennas and Propagation, Vol.2008, Issue.2, pp.2-11, 2008.

[16] M. Xie, Q. Guo, Y. Wu, "Design of a miniaturized UWB antenna with band-notched and high frequency rejection capability", Journal of Electromagnetic Waves and Applications, vol.25, Issue.9, pp.1103-1112, 2011.

[17] CC. Lin, P. Jin, RW. Ziolkowski, "Single dual and triband-notched ultrawideb and (UWB) antennas using capacitivelyloaded loop (CLL) resonators", IEEE Transactions on Antennas and Propagation, vol. 60, Issue. 1, pp. 102-109, 2012

[18] SJ. Wu, JH. Tarng, "Planar band-notched ultra-wideband antenna with square-looped and end-coupled resonator", IET Microwaves Antennas and Propagation, Vol. 5, Issue.10, pp.1227-1233, 2011.

[19] SK. Mishra, J. Mukherjee, "Compact printed dual band notched U-shape UWB antenna", Progress in Electromagnetics Research C, Vol.27, Issue.3, pp. 169-181, 2012

[20] R. Azim, MT. Islam, "Compact planar UWB antenna withband notched characteristics forWLANand DSRC", Progress in Electromagnetics Research Letters, vol. 133, Issue.2, pp. 391-406, 2013

[21] MT. Islam, R. Azim, AT. Mobashsher, "Triple band notched planar UWB antenna using parasitic strips", Progress in Electromagnetics Research, Vol. 129, Issue.6, pp. 161-179, 2012.

[22] JY. Kim, B. Oh, N. Kim, S. Lee, "Triple band-notched UWB antenna based on complementary meander line SRR", Electronics Letters, vol. 48, Issue.2, pp.1-15, 2012.

[23]] S. Natarajamani, K. B. Santanu, KP. Sarat, "A triple band notched planar antenna for UWB applications", Journal of Electromagnetic Waves and Applications, Vol.27, Issue.9, pp.1178-1186, 2013.

[24] RY. Panda, SR. Aditya, S. Rakhesh, "A Compact 3.4/5.5 GHz Dual Band-Notched UWB Monopole Antenna with Nested U-Shaped Slots", IEEE International conference on Computing Communication and Networking Technologies, India, pp.1-4, 2010.

[25] D. Punitharaj, S. Kalaimani, "Design and Fabrication of Microstrip Antenna for UWB Applications", International Journal of Emerging Trends in Electrical and Electronics, Vol.3, Issue.2, pp.60-63, 2013.

[26] RC. Jain, MM. Kadam, " Band Notching Methods Used In UWB Antennas- A Study", International Research Journal of Engineering and Technology, Vol.2, Issue.7, pp 260-262, 2015.

[27] C. Abdelhalim, D. Farid, "A Compact Planar UWB Antenna with Triple Controllable Band-Notched Characteristics", International Journal of Antennas and Propagation,Vol.2014, Issue.4, pp.1-10, 2014.